MCGINN & GIBB, PLLC
A PROFESSIONAL LIMITED LIABILITY COMPANY
PATENTS, TRADEMARKS, COPYRIGHTS, AND INTELLECTUAL PROPERTY LAW
8321 OLD COURTHOUSE ROAD, SUITE 200
VIENNA, VIRGIN IA 22182-3817
TELEPHONE (703) 761-4100
FACSIMILE (703) 761-2375; (703) 761-2376

APPLICATION FOR UNITED STATES LETTERS PATENT

APPLICANT: Shigeo Nishitoba

FOR: **DRIVING CIRCUIT AND CONSTANT DRIVING APPARATUS USING THE SAME**

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DRIVING CIRCUIT AND CONSTANT CURRENT DRIVING APPARATUS USING THE SAME

Background of the Invention

1. Field of the Invention

The present invention relates to a driving circuit and a constant current driving apparatus using the same.

2. Description of the Related Art

Conventionally, a driving circuit which has a current mirror circuit has been used in order to drive a load at a constant current. Fig. 1 shows an example of such a conventional driving circuit. This driving circuit is composed of a current mirror circuit and a reference current setting resistor R.

The current mirror circuit is composed of a plurality of PNP transistors Tr_0 to Tr_n. In this current mirror circuit, it is assumed that a power supply terminal and the respective PNP transistors Tr_0 to Tr_n are physically arranged at positions shown in Fig. 1. In short, the PNP transistor Tr_0 is physically arranged at the closest position to the power supply terminal, and the PNP transistor Tr_n is physically arranged at the farthest position from the power supply terminal.

Bases of the plurality of PNP transistors Tr_0 to Tr_n are connected to each other. Emitters are commonly

connected through a common power supply line to the power supply terminal, and collectors are connected to output terminals O_1 to O_n, respectively. The base of the PNP transistor Tr_0 arranged at a first stage of this current mirror circuit is connected to the collector of the PNP transistor Tr_0 so that a so-called diode coupling is established.

In this current mirror circuit, a current of which value is substantially equal to that flowing through the collector of the PNP transistor Tr_0, is flowed through each of the collectors of the PNP transistors Tr_1 to Tr_n, and outputted as output currents from the output terminals O_1 to O_n. Accordingly, a load that is set at an independent potential is current-driven. The collector of the PNP transistor Tr_0 arranged at the first stage is connected through the reference current setting resistor R to a ground.

This reference current setting resistor R enables a reference current I_{ref} flowing through the collector of the PNP transistor Tr_0 to be adjusted. Thus, the suitable selection of the value of the reference current setting resistor R enables a current having a desired value to flow through the output terminals O_1 to O_n. Hence, it is possible to drive a load requiring a constant current drive. This conventional driving circuit is generally configured,

for example, as one semiconductor integrated circuit (IC).

Recently, as the load requiring the constant current drive, there are an LED display panel composed by arraying a plurality of light emitting diodes (hereafter, referred to as "LED"), an organic electroluminescence (hereafter, referred to as "EL") display panel composed by arraying a plurality of organic EL elements using the electroluminescence phenomenon of organic compound, and the like.

In those display panels, the large number of LEDs and the large number of organic EL devices are used as light emission devices. Thus, a constant current driving apparatus can not be constituted only by one driving circuit (IC). Generally, the large number of light emission devices constituting the display panel are divided into a plurality of blocks, and the plurality of blocks are driven by a plurality of driving circuits, respectively.

In this case, when there is an irregular component in an output current outputted from the output terminal of each driving circuit, this irregularity causes a variation to be induced in a light emission amount of the light emission device. As a result, a display irregularity is generated in the display panel. Therefore, in order that the output current outputted from the output terminal of each

driving circuit is made constant, the reference current is made constant by adjusting the resistive value of the reference current setting resistor R installed in each driving circuit.

As mentioned above, the conventional driving circuit employs the method of independently setting an input current of the current mirror circuit by adjusting the resistive value. Thus, when the plurality of driving circuits are used to drive the display panel at the constant current, it is difficult to reduce the variation in the reference currents of driving circuits.

In order to solve such problems, Japanese Laid Open Patent Application (JP-A 2000-293245) discloses "Constant Current Driving Apparatus And Constant Current Drive Semiconductor Integrated Circuit". In this constant current driving apparatus, a plurality of constant current driver ICs are used in order to drive an organic EL element of an EL display panel at a constant current.

A constant current driver circuit and a control circuit are contained in each of the constant current driver ICs. A reference current generating circuit is built in each of the constant current driver ICs. A reference output current generated on the basis of a reference resistor is outputted from a reference terminal. The reference output current outputted from

the reference current generating circuit is inputted to a reference current input terminal of each constant current driver IC. The drive currents having the same current value are respectively outputted from the output terminals. The drive current is controlled so as to be turned on and off by each control circuit.

Due to this configuration, by using the plurality of the constant current driver ICs, a large number of loads can be driven at the small variation in the output current among the constant current driver ICs.

However, in the case of the driving circuit constituted by the current mirror circuit having the large number of output terminals, the impedance of the common power supply line of the current mirror circuit causes a current ratio to be deviated on the basis of the position of the output terminal. Fig. 2 shows the relation between the deviation in the current ratio and the wiring resistance value of the current mirror circuit.

As can be understood from Fig. 2, as the wiring resistance value of the current mirror circuit is increased, namely, as the position of a cell (transistor) is located farther from the power supply terminal, the deviation in the current ratio is made larger. As a result, a difference occurs between a brightness of a light emission device driven by a

transistor located close to the power supply terminal and a brightness of a light emission device driven by a transistor located far from the power supply terminal.

Thus, as shown in Fig. 3A, when the four driving circuits drive the light emission devices of the display panel, the output current of each of the driving circuits is decreased as they are located farther from the power supply terminal, as indicated by solid lines of Fig. 3B. This results in the large difference between an output current from an output terminal on an end side of one driving circuit and an output current from an output terminal on a beginning side of a driving circuit adjacent thereto, as indicated by A of Fig. 3B. This results in the evident brightness difference in the boundary between the light emission device driven by the one driving circuit and the light emission device driven by the driving circuit adjacent thereto. Hence, the picture quality is extremely dropped.

Dashed lines in Fig. 3B indicate the variation in the output current, which variation is generated based on the variation in the electrical characteristic caused by the product process of the driving circuit. Although, this problem can be logically solved by suitably selecting the reference current by properly selecting the value of the

reference current setting resistor R, actually, it is difficult to suppress the variation in the reference current to a small value, as mentioned above.

In order to solve the above-mentioned problems, namely, in order to reduce a slope of a property line of Fig. 2, it is necessary to reduce the impedance of the common power supply line. For this purpose, it is necessary to make the width of the common power supply line wider or install a plurality of power supply terminals. Also, in order to reduce the variation in the reference current of the current mirror circuit, it is necessary to carry out a trimming and the like or manage the semiconductor integrated circuit constituting the driving circuit at a wafer unit. They result in the factor of the cost increase when the driving circuit is constituted by the semiconductor integrated circuit.

Summary of the Invention

Therefore, an object of the present invention is to provide a driving circuit, in which a variation in an output current between driving circuits adjacent to each other can be suppressed to be small and a cost is inexpensive, and a constant current driving apparatus using the same.

Means for achieving the object will be described below using reference numerals and symbols used in

"Embodiments of the invention". These reference numerals and symbols are added so that relation between the description of "Scope of the Patent to be Claimed" and the description of "Embodiments of the invention" is made clear. However, it is never permitted to use the reference numerals and symbols for the interpretation of technical scopes of the inventions described in "Scope of the Patent to be Claimed" and the description of "Embodiments of the invention".

A driving circuit according to a first aspect of the present invention comprises a first current mirror circuit (10, 10a, 10b, 10c, 10d, 10e, 10f, 10g) and a second current mirror circuit (20, 20a, 20b, 20c, 20d, 20e). The first current mirror circuit (10, 10a, 10b, 10c, 10d, 10e, 10f, 10g) outputs a plurality of output currents, each of which corresponds to a reference current. The second current mirror circuit which converts a polarity of an output current outputted from a final stage of the first current mirror circuit and outputs the converted output current.

This driving circuit can be configured as a current discharging type. In this case, the first current mirror circuit (10, 10a, 10b, 10c, 10d, 10e, 10f, 10g) may be configured so as to comprise a reference current input terminal (12) to which the reference current is supplied, a power supply terminal

(11) to which power is supplied, a first circuit (Tr_0) provided between the reference current input terminal (12) and the power supply terminal (11) to determine the plurality of output currents, a common power supply line (16) which extends from the power supply terminal (11), a plurality of output terminals (O_1 to O_n), a plurality of second circuits (Tr_1 to Tr_n) provided between the common power supply line and the plurality of output terminals (O_1 to O_n) to output one of the plurality of output currents determined by the first circuit (Tr_0) through the plurality of output terminals (O_1 to O_n) and a third circuit (Tr_{n+1}) provided at a next stage of the plurality of second circuits (Tr_1 to Tr_n) as the final stage of the first current mirror circuit (10, 10a, 10b, 10c, 10d, 10e, 10f, 10g) to output the output current determined by the first circuit (Tr_0). The second current mirror circuit (20, 20a, 20b, 20c, 20d, 20e) may be configured so as to convert the polarity of the output current outputted from the third circuit (Tr_{n+1}) and outputs the converted output current through a reference current output terminal (13).

Actually, this driving circuit may be configured such that the first circuit (Tr_0), the second circuits (Tr_1 to Tr_n) and the third circuit (Tr_{n+1}) included in the first current mirror circuit (10, 10a, 10b, 10c, 10d, 10e, 10f, 10g) are constituted by PNP transistors,

and the second current mirror circuit (20, 20a, 20b, 20c, 20d, 20e) is constituted by NPN transistors. In this case, it may be configured such that at least one of the first circuit (Tr_0) and the second current mirror circuit (20, 20a, 20b, 20c, 20d, 20e) has a base current compensating circuit (Tr_x and/or Tr_y).

This driving circuit may be configured such that the first circuit (Tr_0), the second circuits (Tr_1 to Tr_n) and the third circuit (Tr_{n+1}) included in the first current mirror circuit (10, 10a, 10b, 10c, 10d, 10e, 10f, 10g) are constituted by P-channel MOS transistors, and the second current mirror circuit (20, 20a, 20b, 20c, 20d, 20e) is constituted by N-channel MOS transistors.

The power supply terminal (11) of the driving circuit of the current discharging type as mentioned above can be configured so as to be pulled out from a center of the common power supply line (16). Also, the power supply terminal can be configured so as to pulled out from a plurality of positions of the common power supply line (16).

Also, the driving circuit of the present invention can be configured as a current sucking type. In this case, the first current mirror circuit (10, 10a, 10b, 10c, 10d, 10e, 10f, 10g) comprises a reference current input terminal (12) to which the reference current is supplied, a ground terminal (14)

which is connected to a ground, a first circuit (Tr_0) provided between the reference current input terminal (12) and the ground terminal (14) to determine the plurality of output currents, a common ground line (14) which extends from the ground terminal (14), a plurality of output terminals (O_1 to O_n), a plurality of second circuits (Tr_1 to Tr_n) provided between the common ground line (17) and the plurality of output terminals (O_1 to O_n) to output one of the plurality of output currents determined by the first circuit (Tr_0) through the plurality of output terminals (O_1 to O_n) and a third circuit (Tr_{n+1}) provided at a next stage of the plurality of second circuits (Tr_1 to Tr_n) as the final stage of the first current mirror circuit (20, 20a, 20b, 20c, 20d, 20e) to output the output current determined by the first circuit. The second current mirror circuit (20, 20a, 20b, 20c, 20d, 20e) can be configured so as to convert the polarity of the output current outputted from the third circuit (Tr_{n+1}) and outputs the converted output current through a reference current output terminal (13).

Actually, this driving circuit can be configured such that the first circuit (Tr_0), the second circuits (Tr_1 to Tr_n) and the third circuit (Tr_{n+1}) included in the first current mirror circuit (10, 10a, 10b, 10c, 10d, 10e, 10f, 10g) are constituted by NPN transistors, and the second current mirror circuit (20, 20a, 20b,

20c, 20d, 20e) is constituted by PNP transistors. In this case, it may be configured such that at least one of the first circuit (Tr_0) and the second current mirror circuit (20, 20a, 20b, 20c, 20d, 20e) has a base current compensating circuit (Tr_x and/or Tr_y).

This driving circuit may be configured such that the first circuit (Tr_0), the second circuits (Tr_1 to Tr_n) and the third circuit (Tr_{n+1}) included in the first current mirror circuit (10, 10a, 10b, 10c, 10d, 10e, 10f, 10g) are constituted by N-channel MOS transistors, and the second current mirror circuit (20, 20a, 20b, 20c, 20d, 20e) is constituted by P-channel MOS transistors.

The ground terminal (14) of the driving circuit of the current sucking type as mentioned above can be configured so as to be pulled out from a center of the common ground line (17). Also, the ground terminal (14) can be configured so as to be pulled out from a plurality of positions of the common ground line (17).

A constant current driving apparatus according to a second aspect of the present invention is composed of a plurality of driving circuits (1_1 to 1_N) connected through terminals (12 and 13) in series, each of which comprises a first current mirror circuit (10, 10a, 10b, 10c, 10d, 10e, 10f, 10g) which outputs a plurality of output currents each of which corresponds to a reference current and a second

current mirror circuit (20, 20a, 20b, 20c, 20d, 20e) which converts a polarity of an output current outputted from a final stage of the first current mirror circuit (10, 10a, 10b, 10c, 10d, 10e, 10f, 10g) and outputs the converted output current.

Brief Description of the Drawings

Fig. 1 is a circuit diagram showing a configuration of a conventional driving circuit using a current mirror circuit;

Fig. 2 is an explanatory diagram describing an operation of the driving circuit shown in Fig. 1;

Figs. 3A and 3B are explanatory diagrams describing an operation of a constant current driving apparatus using the driving circuit shown in Fig. 1;

Fig. 4 is a block diagram showing a configuration of a driving circuit according to a first embodiment of the present invention;

Fig. 5 is a circuit diagram showing the configuration of the driving circuit according to the first embodiment of the present invention;

Fig. 6A is a block diagram showing a configuration of a constant current driving apparatus using the driving circuit according to the first embodiment of the present invention;

Fig. 6B is explanatory diagrams describing an operation of a constant current driving apparatus

using the driving circuit according to the first embodiment of the present invention;

Fig. 6C is explanatory diagrams describing an operation of a constant current driving apparatus using the driving circuit according to the seventh embodiment of the present invention;

Fig. 7 is a circuit diagram showing a configuration of a driving circuit according to a second embodiment of the present invention;

Fig. 8 is a circuit diagram showing a first variation of the driving circuit according to the second embodiment of the present invention;

Fig. 9 is a circuit diagram showing a second variation of the driving circuit according to the second embodiment of the present invention;

Fig. 10 is a circuit diagram showing a configuration of a driving circuit according to a third embodiment of the present invention;

Fig. 11 is a circuit diagram showing a configuration of a driving circuit according to a fourth embodiment of the present invention;

Fig. 12 is a circuit diagram showing a first variation of the driving circuit according to the fourth embodiment of the present invention;

Fig. 13 is a circuit diagram showing a second variation of the driving circuit according to the fourth embodiment of the present invention;

Fig. 14 is a circuit diagram showing a configuration of a driving circuit according to a fifth embodiment of the present invention;

Fig. 15 is a circuit diagram showing a configuration of a driving circuit according to a sixth embodiment of the present invention;

Fig. 16 is a circuit diagram showing a configuration of a driving circuit according to a seventh embodiment of the present invention; and

Fig. 17 is a circuit diagram showing a configuration of a variation of the driving circuit according to the seventh embodiment of the present invention.

Description of the Preferred Embodiments

A driving circuit and a constant current driving apparatus according to embodiments of the present invention will be described below with reference to the attached drawings.

(First Embodiment)

A driving circuit according to a first embodiment of the present invention is designed such that a current mirror circuit of a current discharging type, which discharges a current from an output terminal, is constituted by bipolar transistors.

Fig. 4 is a block diagram showing a configuration of a driving circuit according to the

first embodiment of the present invention. This driving circuit is composed of a first current mirror circuit 10 and a second current mirror circuit 20.

The first current mirror circuit 10 has a power supply terminal 11, a reference current input terminal 12 and output terminals O_1 to O_n ("n" is an integer equal to or greater than 2). This first current mirror circuit 10 outputs output currents corresponding to an input current I_{ref} which is supplied to the reference current input terminal 12, from the output terminals O_1 to O_n. Also, one of the output currents from the first current mirror circuit 10 is supplied to the second current mirror circuit 20.

The second current mirror circuit 20 converts a polarity of the output current from the first current mirror circuit 10, and then outputs it from a reference current output terminal 13. A ground terminal 14 is equipped in the second current mirror circuit 20.

Fig. 5 is a circuit diagram showing the detailed circuit configuration of the above-mentioned driving circuit. The first current mirror circuit 10 is composed of a plurality of PNP transistors Tr_0 to Tr_{n+1}. The PNP transistor Tr_0 corresponds to a first circuit of the present invention, the plurality of PNP transistors Tr_1 to Tr_n correspond to a plurality of second circuits of the present invention, and the PNP

transistor Tr_{n+1} corresponds to a third circuit of the present invention.

In this first current mirror circuit 10, the power supply terminal 11 and the PNP transistors Tr_0 to Tr_{n+1} are physically arranged at positions shown in Fig. 5. In short, the PNP transistor Tr_0 is physically arranged at the closest position to the power supply terminal 11, and the PNP transistor Tr_{n+1} is physically arranged at the farthest position from the power supply terminal 11.

Respective bases of the plurality of PNP transistors Tr_0 to Tr_{n+1} are connected to each other. Emitters are commonly connected to each other through a common power supply line 16, which is extendedly located from the power supply terminal 11. The base of the PNP transistor Tr_0 arranged at a first stage of the first current mirror circuit 10 is connected to a collector thereof. Accordingly, the so-called diode coupling is established.

A collector of the PNP transistor Tr_{n+1} arranged at a final stage is connected to the second current mirror circuit 20. Collectors of the PNP transistors Tr_1 to Tr_n arranged at middle stages are connected to the output terminals O_1 to O_n, respectively.

The second current mirror circuit 20 is composed of an NPN transistor Tr_a and an NPN transistor Tr_b. A base of the NPN transistor Tr_a is connected to a

collector thereof so that the so-called diode coupling is established. An emitter of the NPN transistor Tr_a is connected to the ground terminal 14. Also, a base of the NPN transistor Tr_b is connected to the base of the NPN transistor Tr_a, a collector is connected to the reference current output terminal 13, and an emitter is connected to the ground terminal 14.

A current substantially equal to that flowing through the NPN transistor Tr_a flows through this NPN transistor Tr_b. In this case, a direction of the current flowing through the NPN transistor Tr_b is equal to that of the current flowing through the NPN transistor Tr_a. Thus, since the NPN transistor Tr_b functions so as to suck the current, the polarity of the current outputted from the PNP transistor Tr_{n+1} is converted such that the polarity is inverted.

An example of a constant current driving apparatus constituted by connecting N ("N" is an integer equal to or greater than 2) driving circuits having the above-mentioned configuration will be described below.

Fig. 6A is a block diagram showing the configuration of the constant current driving apparatus in which the N driving circuits are connected in serial. A reference current input terminal 12 of a first driving circuit 1_1 arranged at a first stage is connected through a reference current

setting resistor R to the ground. This reference current setting resistor R determines a reference current I_{ref} flowing through the collector of the PNP transistor Tr_0 included in the first current mirror circuit 10 of the first driving circuit 1_1. Thus, the suitable selection of the value of the reference current setting resistor R enables an output current having a desired value to be obtained from the output terminals O_1 to O_n of the first driving circuit 1_1.

A reference current output terminal 13 of the first driving circuit 1_1 is connected to a reference current input terminal 12 of a second driving circuit 1_2 arranged at a next stage. In the same manner, the respective driving circuits are connected in series. A reference current output terminal 13 of an N-th driving circuit 1_N arranged at a final stage is not connected.

In the constant current driving apparatus having the above-mentioned configuration, a value of the current discharged from the output terminal O_n of the first driving circuit 1_1 is substantially equal to that of a current sucked from the reference current output terminal 13 of the first driving circuit 1_1, and a value of the current discharged from the reference current input terminal 12 of the second driving circuit 1_2 is substantially equal to that of a current discharged from the output terminal O_1 of the second

driving circuit 1_2. Thus, a value of an output current discharged from the output terminal O_n of the first driving circuit 1_1 is substantially equal to that of an output current discharged from the output terminal O_1 of the second driving circuit 1_2.

As a result, the values of the output currents in the boundary between the first driving circuit 1_1 and the second driving circuit 1_2 are substantially equal to each other, as shown in Fig. 6B. This equality is similar in the other driving circuits. That is, the values of the output currents in the boundary between the driving circuits adjacent to each other are substantially equal to each other. Thus, if this constant current driving apparatus is applied to a display panel, there is not a substantial brightness difference in a boundary between a light emission device driven by one driving circuit and another light emission device driven by a driving circuit adjacent thereto. Hence, it is possible to attain the picture having high quality.

(Second Embodiment)

A driving circuit according to a second embodiment of the present invention is designed such that a base current compensating circuit is added to each of the first and second current mirror circuits in the driving circuit according to the first embodiment.

Fig. 7 is a circuit diagram showing the configuration of the driving circuit according to the second embodiment. In this driving circuit, a first current mirror circuit 10a is configured such that a PNP transistor Tr_x serving as the base current compensating circuit is added to the first current mirror circuit 10 of the driving circuit according to the first embodiment.

A base of the PNP transistor Tr_x is connected to the collector of the PNP transistor Tr_0, an emitter is connected to the base of the PNP transistor Tr_0, and a collector is connected to a ground terminal 14.

In the aforementioned driving circuit according to the first embodiment, a base current of a transistor whose current amplification factor h_{fe} is large is sufficiently smaller than collector current. Thus, an equation "reference current I_{ref} = collector current I_c" can be defined by ignoring the base current. However, if the base current can not be ignored, the collector current I_c can be made closer to the reference current I_{ref} by adding the base current compensating circuit constituted by the transistor Tr_x.

Also, a second current mirror circuit 20a is configured such that an NPN transistor Tr_y serving as a base current compensating circuit is added to the second current mirror circuit 20 of the driving circuit according to the first embodiment.

A base of the NPN transistor Tr_y is connected to the collector of an NPN transistor Tr_a, an emitter is connected to the base of the NPN transistor Tr_a, and a collector is connected to a second power supply terminal 15. A power supply suitable for compensating the base current of the NPN transistor Tr_a is impressed to the second power supply terminal 15.

The addition of the base current compensating circuit constituted by the NPN transistor Tr_y enables a collector current I_c of the NPN transistor Tr_a to be closer to the reference current I_{ref} even if the base current can not be ignored.

As mentioned above, according to the driving circuit of the second embodiment of the present invention, the current flowing through the reference current input terminal 12 can be made coincident with the output current outputted from the output terminals O_1 to O_n with the high accuracy. Also, the current flowing through the collector of the PNP transistor Tr_{n+1} arranged at the final stage of the first current mirror circuit 10a can be made coincident with the current flowing through the reference current output terminal 13 with the high accuracy. Thus, it is possible to carry out the precise current control.

It should be noted that the second embodiment is designed such that the base current compensating circuit is installed in each of the first current

mirror circuit 10a and the second current mirror circuit 20a. However, as shown in Fig. 8, the base current compensating circuit may be installed only in the second current mirror circuit 20a. Also, as shown in Fig. 9, the base current compensating circuit may be installed only in the first current mirror circuit 10a.

(Third Embodiment)

A driving circuit according to a third embodiment of the present invention is designed such that a current mirror circuit of a current sucking type, which sucks a current from an output terminal, is constituted by bipolar transistors. It should be noted that this embodiment will be described below by giving the symbols similar to those of the first embodiment to the portions corresponding to the first embodiment.

Fig. 10 is a circuit diagram showing a detailed circuit configuration of a driving circuit according to the third embodiment of the present invention. This driving circuit is composed of a first current mirror circuit 10b and a second current mirror circuit 20b.

The first current mirror circuit 10b is composed of a plurality of NPN transistors Tr_0 to Tr_{n+1}. The NPN transistor Tr_0 corresponds to a first circuit of the present invention, a plurality of NPN transistors Tr_1 to Tr_n correspond to a plurality of second circuits of

the present invention, and an NPN transistor Tr_{n+1} corresponds to a third circuit of the present invention.

In this first current mirror circuit 10b, the ground terminal 14 and the NPN transistors Tr_0 to Tr_{n+1} are physically arranged at positions shown in Fig. 10. In short, the NPN transistor Tr_0 is physically arranged at the closest position to the ground terminal 14, and the NPN transistor Tr_{n+1} is physically arranged at the farthest position from the ground terminal 14.

Respective bases of the plurality of NPN transistors Tr_0 to Tr_{n+1} are connected to each other. Emitters are commonly connected to each other through a common ground line 17 extendedly located from the ground terminal 14. The base of the NPN transistor Tr_0 arranged at a first stage of the first current mirror circuit 10b is connected to a collector thereof. Accordingly, the so-called diode coupling is established.

A collector of the transistor Tr_{n+1} arranged at a final stage is connected to the second current mirror circuit 20b. Collectors of the NPN transistors Tr_1 to Tr_n arranged at the middle stages are connected to the output terminals O_1 to O_n, respectively.

The second current mirror circuit 20b is composed of a PNP transistor Tr_a and a PNP transistor Tr_b. A base of the PNP transistor Tr_a is connected to a

collector thereof so that the so-called diode coupling is established. An emitter of the PNP transistor Tr_a is connected to the power supply terminal 11. Also, a base of the PNP transistor Tr_b is connected to the base of the PNP transistor Tr_a, a collector thereof is connected to the reference current output terminal 13, and an emitter thereof is connected to the power supply terminal 11.

A current substantially equal to that flowing through the PNP transistor Tr_a flows through this PNP transistor Tr_b. In this case, a direction of the current flowing through the PNP transistor Tr_b is equal to that of the current flowing through the PNP transistor Tr_a. Thus, since the PNP transistor Tr_b functions so as to discharge the current, the polarity of the current outputted from the NPN transistor Tr_{n+1} is converted such that the polarity is inverted.

The operation of the driving circuit having the above-mentioned configuration is equal to that of the driving circuit according to the first embodiment except that the PNP transistors and the NPN transistors are exchanged.

According to the driving circuit of the third embodiment of the present invention, it is possible to drive the light emission device having the current discharging type. Also, similarly to the first embodiment, if a constant current driving apparatus

configured by using the plurality of driving circuits is applied to the display panel, there is not a substantial brightness difference in a boundary between a light emission device driven by one driving circuit and a light emission device driven by another driving circuit adjacent thereto. Hence, it is possible to attain the picture having high quality.

(Fourth Embodiment)

A driving circuit according to a fourth embodiment of the present invention is designed such that a base current compensating circuit is installed in each of the first and second current mirror circuits in the driving circuit according to the third embodiment.

Fig. 11 is a circuit diagram showing the configuration of the driving circuit according to the fourth embodiment. In this driving circuit, a first current mirror circuit 10c is configured such that an NPN transistor Tr_x serving as the base current compensating circuit is added to the first current mirror circuit 10b of the driving circuit according to the third embodiment.

A base of the NPN transistor Tr_x is connected to a collector of an NPN transistor Tr_0, an emitter is connected to a base of the NPN transistor Tr_0, and a collector is connected to a second power supply terminal 15. A power supply suitable for compensating

the base current of the NPN transistor Tr_0 is impressed to the second power supply terminal 15.

In the aforementioned driving circuit according to the third embodiment, a base current of a transistor having a large h_{fe} is sufficiently smaller than a collector current. Thus, an equation "reference current I_{ref} = collector current I_c" can be defined by ignoring the base current. However, if the base current can not be ignored, the collector current I_c of the NPN transistor Tr_0 can be made closer to the reference current I_{ref} by adding the base current compensating circuit constituted by the NPN transistor Tr_x.

Also, a second current mirror circuit 20c is configured such that a PNP transistor Tr_y serving as a base current compensating circuit is added to the second current mirror circuit 20b of the driving circuit according to the third embodiment.

A base of the PNP transistor Tr_y is connected to a collector of a PNP transistor Tr_a, an emitter is connected to a base of the PNP transistor Tr_a, and a collector is connected to a ground terminal 14.

The addition of the base current compensating circuit constituted by the PNP transistor Tr_y enables collector current I_c to be closer to the reference current I_{ref} even if the base current can not be ignored, as mentioned above.

As mentioned above, according to the driving circuit of the fourth embodiment of the present invention, the current flowing through the reference current input terminal 12 can be made coincident with the output current outputted from the output terminals O_1 to O_n with the high accuracy. Also, the current flowing through the collector of the NPN transistor Tr_{n+1} arranged at the final stage of the first current mirror circuit 10c can be made coincident with the current flowing through the reference current output terminal 13 with the high accuracy. Thus, it is possible to carry out the precise current control.

It should be noted that the fourth embodiment is designed such that the base current compensating circuit is installed in each of the first current mirror circuit 10c and the second current mirror circuit 20c. However, as shown in Fig. 12, the base current compensating circuit may be installed only in the second current mirror circuit 20c. Also, as shown in Fig. 13, the base current compensating circuit may be installed only in the first current mirror circuit 10c.

(Fifth Embodiment)

A driving circuit according to a fifth embodiment of the present invention is designed such that a current mirror circuit of a current discharging type, which discharges a current from an output

terminal, is constituted by MOS transistors. It should be noted that this embodiment will be described below by giving the symbols similar to those of the first embodiment to the portions corresponding to the first embodiment.

Fig. 14 is a circuit diagram showing the detailed circuit configuration of the driving circuit according to the fifth embodiment of the present invention. This driving circuit is composed of a first current mirror circuit 10d and a second current mirror circuit 20d.

The first current mirror circuit 10d outputs the output currents corresponding to an reference current I_{ref} which is supplied from the reference current input terminal 12, from the output terminals O_1 to O_n. Also, one of the output currents from the first current mirror circuit 10d is supplied to the second current mirror circuit 20d. The second current mirror circuit 20d converts a polarity of the output current outputted from the first current mirror circuit 10d, and outputs it from the reference current output terminal 13.

In detail, the first current mirror circuit 10d is composed of a plurality of P-channel MOS transistors (hereafter, referred to as "PMOS transistor") Tr_0 to Tr_{n+1}. The PMOS transistor Tr_0 corresponds to the first circuit of the present

invention, the plurality of PMOS transistors Tr_1 to Tr_n correspond to the plurality of second circuits of the present invention, and the PMOS transistor Tr_{n+1} corresponds to the third circuit of the present invention.

In this first current mirror circuit 10d, the power supply terminal 11 and the PMOS transistors Tr_0 to Tr_{n+1} are physically arranged at positions shown in Fig. 11. In short, the PMOS transistor Tr_0 is physically arranged at the closest position to the power supply terminal 11, and the PMOS transistor Tr_{n+1} is physically arranged at the farthest position from the power supply terminal 11.

Respective gates of the plurality of PMOS transistors Tr_0 to Tr_{n+1} are connected to each other. Sources are commonly connected to each other through the common power supply line 16, which is extendedly located from the power supply terminal 11. The gate of the PMOS transistor Tr_0 arranged at a first stage of the first current mirror circuit 10d is connected to a drain thereof.

A drain of the PMOS transistor Tr_{n+1} arranged at a final stage is connected to the second current mirror circuit 20d. Drains of the PMOS transistors Tr_1 to Tr_n arranged at middle stages are connected to the output terminals O_1 to O_n, respectively.

The second current mirror circuit 20d is

composed of an N-channel MOS transistor (hereafter, referred to as "NMOS Transistor") Tr_a and an NMOS transistor Tr_b. A gate of the NMOS transistor Tr_a is connected to a drain. A source of the NMOS transistor Tr_a is connected to the ground terminal 14. Also, a gate of the NMOS transistor Tr_b is connected to the gate of the NMOS transistor Tr_a, a drain thereof is connected to the reference current output terminal 13, and a source thereof is connected to the ground terminal 14.

A current substantially equal to that flowing through the NMOS transistor Tr_a flows through this NMOS transistor Tr_b. In this case, a direction of the current flowing through the NMOS transistor Tr_b is equal to that of the current flowing through the NMOS transistor Tr_a. Thus, since the NMOS transistor Tr_b functions so as to suck the current, the polarity of the current outputted from the NMOS transistor Tr_{n+1} is converted such that the polarity is inverted.

The operation of the driving circuit having the above-mentioned configuration is equal to that of the driving circuit according to the first embodiment except that the PNP transistors and the NPN transistors are replaced by the PMOS transistors and the NMOS transistors, respectively. Even the driving circuit according to this fifth embodiment can provide the effect similar to that of the first embodiment.

(Sixth Embodiment)

A driving circuit according to a sixth embodiment of the present invention is designed such that a current mirror circuit of a current sucking type, which sucks a current from an output terminal, is constituted by MOS transistors. It should be noted that this embodiment will be described below by giving the symbols similar to those of the first embodiment to the portions corresponding to the first embodiment.

Fig. 15 is a circuit diagram showing the detailed circuit configuration of the driving circuit according to the sixth embodiment of the present invention. This driving circuit is composed of a first current mirror circuit 10e and a second current mirror circuit 20e.

The first current mirror circuit 10e is composed of a plurality of NMOS transistors Tr_0 to Tr_{n+1}. The NMOS transistor Tr_0 corresponds to a first circuit of the present invention, a plurality of NMOS transistors Tr_1 to Tr_n correspond to a plurality of second circuits of the present invention, and an NMOS transistor Tr_{n+1} corresponds to a third circuit of the present invention.

In this first current mirror circuit 10e, the ground terminal 14 and the NMOS transistors Tr_0 to Tr_{n+1} are physically arranged at positions shown in Fig. 15. In short, the NMOS transistor Tr_0 is physically

arranged at the closest position to the ground terminal 14, and the NMOS transistor Tr_{n+1} is physically arranged at the farthest position from the ground terminal.

Respective gates of the plurality of NMOS transistors Tr_0 to Tr_{n+1} are connected to each other. Sources are commonly connected to each other through a common ground line 17 extendedly located from the ground terminal 14. The gate of the NMOS transistor Tr_0 arranged at a first stage of the first current mirror circuit 10e is connected to a drain thereof.

A drain of the NMOS transistor Tr_{n+1} arranged at a final stage is connected to the second current mirror circuit 20e. Drains of the NMOS transistors Tr_1 to Tr_n arranged at the middle stages are connected to the output terminals O_1 to O_n, respectively.

The second current mirror circuit 20e is composed of a PMOS transistor Tr_a and a PMOS transistor Tr_b. A gate of the PMOS transistor Tr_a is connected to a drain. A source of the PMOS transistor Tr_a is connected to the power supply terminal 11. Also, a gate of the PMOS transistor Tr_b is connected to the gate of the PMOS transistor Tr_a, a drain thereof is connected to the reference current output terminal 13, and a source thereof is connected to the power supply terminal 11.

A current substantially equal to that flowing

through the PMOS transistor Tr_a flows through this PMOS transistor Tr_b. In this case, a direction of the current flowing through the PMOS transistor Tr_b is equal to that of the current flowing through the PMOS transistor Tr_a. Thus, since the PMOS transistor Tr_b functions so as to discharge the current, the polarity of the current outputted from the NMOS transistor Tr_{n+1} is converted such that the polarity is inverted.

The operation of the driving circuit having the above-mentioned configuration is equal to that of the driving circuit according to the third embodiment except that the NMOS transistors and the PMOS transistors are exchanged.

According to the driving circuit of the sixth embodiment of the present invention, it is possible to drive the light emission device having the current discharging type. Also, similarly to the third embodiment, if a constant current driving apparatus configured by using the plurality of driving circuits is applied to the display panel, there is not a substantial brightness difference in a boundary between a light emission device driven by one driving circuit and a light emission device driven by another driving circuit adjacent thereto. Hence, it is possible to attain the picture having the high quality

(Seventh Embodiment)

In a driving circuit according to a seventh

embodiment of the present invention, the physical position of the power supply terminal of the first current mirror circuit of the driving circuit according to the first embodiment is changed.

Fig. 16 is a circuit diagram showing a configuration of the driving circuit according to the seventh embodiment of the present invention. This driving circuit is equal to that of the first embodiment except that the power supply terminal 11 is disposed at a physical center of a common power supply line 16 through which emitters of NPN transistors Tr_0 to Tr_{n+1} are connected to each other. Here, the center implies a portion between a first portion where the emitter of the PNP transistors Tr_0 is formed and a second portion where the emitter of the PNP transistor Tr_{n+1} is formed. Preferably, the center may be located at a substantial center between the first portion and the second portion.

According to this configuration, an output current outputted from the output terminal at the center out of output currents outputted from the output terminals O_1 to O_n of the driving circuit is the largest. The output currents become gradually smaller toward the side of the output terminal O_1 and the side of the output terminal O_n. That is, they form a shape of a mountain.

Thus, when the N driving circuits according to

this seventh embodiment are used to configure a constant current driving apparatus, the output currents outputted from the output terminals O_1 to O_n of the respective driving circuits form a shape of the continuous mountains, as shown in Figs. 6C.

According to this configuration, the output currents in the boundary between the driving circuits adjacent to each other are substantially equal. Thus, if this constant current driving apparatus is applied to a display panel, the picture having the high quality can be obtained similarly to the first embodiment. Moreover, a difference between the output current from the first driving circuit and the output current from the N-th driving circuit is smaller as compared with the case when the N driving circuits according to the first embodiment are used to configure the constant current driving apparatus. Hence, when this constant current driving apparatus is applied to the display panel, a difference between a brightness of one end of a screen and a brightness of another end is small to accordingly generate the picture having the high quality.

It should be noted that the driving circuit according to the fifth embodiment can be also configured so as to pull out the power supply terminal 11 from the center of the common power supply line 16. Also, the third and fourth embodiments can be

configured so as to pull out the ground terminal 14 from the center of the common ground line 17. All of the cases can provide the effects similar to the above-mentioned effects.

Fig. 17 is a circuit diagram showing a configuration of a variation of the driving circuit according to the seventh embodiment of the present invention. This driving circuit is equal to that of the first embodiment except that the power supply terminal 11 is pulled out from a plurality of positions of the common power supply line 16 through which the PNP transistors Tr_0 to Tr_{n+1} are connected. This case can be configured such that the common power supply line 16 is divided into m components ("m" is an integer equal to or greater than 3) and (m-1) wires are pulled out from the respective divided points and connected to the power supply terminal 11. Fig. 17 shows an example of a case of "m=3". It should be noted that when the common power supply line 16 is divided into the m components, it is desired to be divided such that a length of a division piece at each of both ends among the m division pieces becomes half that of the division piece except both ends. For example, in the example of "m=3" shown in Fig. 17, the common power supply line 16 is desired to be divided at a rate of 1:2:1. However, it is not always necessary to divide the common power supply line 16 as

mentioned above.

According to this configuration, the output currents outputted from the output terminals O_1 to O_n of the driving circuit form a shape in which a plurality of mountains are continuous, with the output currents outputted from the output terminals located at the plurality of division points as the tops of the mountains.

When the N driving circuits according to this variation of the seventh embodiment are used to configure the constant current driving apparatus, the plurality of output currents, each of which has a plurality of mountain shapes, outputted from the output terminals O_1 to O_n of each driving circuit are continues.

According to this configuration, the output currents in the boundary between the driving circuits adjacent to each other are substantially equal. Thus, if this constant current driving apparatus is applied to the display panel, the picture having the high quality can be obtained similarly to the first embodiment. Moreover, the difference between the output current from the first driving circuit and the output current from the N-th driving circuit is much smaller as compared with the above-mentioned case when it is pulled out from only one portion such as the center of the common power supply line 16. Hence, when

this constant current driving apparatus is applied to the display panel, the difference between a brightness of one end of the screen and a brightness of another end is smaller to thereby generate the picture having the high quality.

It should be noted that the driving circuit according to the fifth embodiment can be also configured so as to pull out the power supply terminal 11 from the plurality of positions of the common power supply line 16. Also, the third and fourth embodiments can be configured so as to pull out the ground terminal 14 from the plurality of positions of the common ground line 17. All of these cases can provide the effects similar to the above-mentioned effects provided by the variation of the seventh embodiment.

As mentioned above, in the driving circuit according to the first to seventh embodiments, the output current at the final stage of the driving circuit of the former stage is used as the input current of the current mirror circuit constituting the driving circuit of the next stage. Thus, even when the plurality of driving circuits are connected, it is possible to reduce the variation of the current in the boundary between the driving circuits. Also, when this driving circuit is constituted by the semiconductor integrated circuit, the cost of the

driving circuit can be reduced.

Also, when the constant current driving apparatus using the driving circuit according to the first to seventh embodiments of the present invention is applied to a display such as an organic EL or the like, it is possible to reduce the variation in the brightness caused by the variation in the output current in the boundary between the driving circuits. Thus, it is possible to provide the picture having the high quality.

As detailed above, according to the present invention, it is possible to provide the inexpensive constant current driving apparatus in which the variation in the output current can be reduced between the driving circuits adjacent to each other.